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Soft Computing Technique Based MPPT Algorithms for Photovoltaic System

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ABSTRACT: Photovoltaic system (PV) have massive potential due to the lavishness of solar energy. Maximum Power Point Tracking (MPPT) algorithm is mainly needed to keep the PV system operated at optimal point. MPP in a PV system improves the overall system utilization efficiency with maximum power. In this paper design and analysis of MPPT algorithms for PV system is expressed. The Simulated Annealing (SA) based MPPT algorithm is proposed in this work. SA MPPT is a simple algorithm and the response of the searching is more reliable.SA based MPPT technique is used to track the maximum power operating point under rapidly varying insolation condition of the PV system. The duty cycle is issued by the SA algorithm is given to the boost converter to regulate and to provide maximum available power to the load. The proposed algorithm and modeling of PV system are simulated in MATLAB 2014Ra Simulink Tool.

KEYWORDS: Photo Voltaic (PV), Simulated Annealing Maximum Power Point Tracking(SA MPPT),Open Circuit Voltage(V_{oc}) , Short Circuit Current (I_{sc}) , Maximum Output Power (P_{max}),

I. INTRODUCTION

Solar PV Power generation emerged significant attention over past decades due to zero fuel cost, clean, low maintenance cost and recent advancement in power conversion technology. Photovoltaic systems can provide electricity to the billions of people without the need of accessing the main grid. When compared with wind energy, solar energy is not site-dependent and easy to access. PV cells exhibit a non-linear Power-Voltage (P-V) characteristic leading to a unique point corresponding to optimal operation. This point is known as the Maximum Power Point (MPP), and this point varies depending on the environmental conditions such as solar irradiance and temperature. Solar irradiance is continuously changing parameter. Rapidly changing solar irradiation level produce a significant effect on the electrical parameter than temperature. Due to that temperature is often taken as constant T=25^{o}C under STC [1, 2].There are numerous MPPT algorithms have been developed [3]. Conventional Perturb & Observe (P&O) MPPT algorithm is popularly used for PV system; due to its easy implementation and its simple operation [4]. But P&O always produces power oscillations around MPP in static weather condition and it has less tracking capability under rapidly changing irradiation condition [5,6]. The analog sliding mode control was designed by Utkin’s theory and fast scale stability analysis[7].An ideal sliding Mode controller requires an infinite switching frequency [14].The current based siding mode controller eliminates low frequency voltage oscillations[16].The incremental conductance (INC) MPPT provides fast tracking of MPP better than P&O [8]. but, INC lags at reduce oscillations around MPP and convergence speed [9,10]. DC-DC converter is used to boost the voltage from low to high level based on the load condition [2]. A variable dc link voltage is used for MPPT in dual purpose as grid feed and harmonics mitigation of loads.[11]The natural perturbation was carried out by means of monitoring the irradiance slope through current monitoring algorithm[12].The PSO based MPPT is mainly used under Partial shading condition which consequences multiple power peak and power losses[13]. PSO needs actual current and voltage curve of PV system [14,15]. The proposed SA MPPT algorithm has better response time, less oscillations and more accurate at each step. This work is to study comparative results of the existing and proposed MPPT algorithms. The simulation is carried out in MATLAB 2014Ra Simulink Tool. The Paper is summarized as follows. The configuration of system is discussed in section II.

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The MPPT control algorithm is explained in section III. Simulation results are discussed in section IV. The conclusion of this paper is drawn in section V.

II. SYSTEM CONFIGURATION

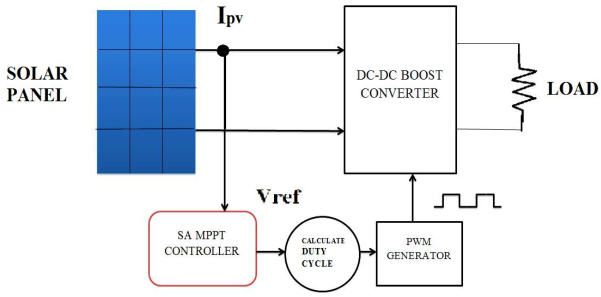

Fig.1 Block diagram of the Proposed System

The Proposed system consists of PV Panel, SA MPPT Controller, Boost Converter, PWM Generator and Load. The specifications of the PV panel are shown in Table.1. The main objective of the work is to propose an efficient Maximum power point tracking algorithm for the Photovoltaic System under rapidly changing irradiation condition. The value of the irradiation is 1000W/m^2 for time duration of 0.5 sec and 800W/m^2 for 0.5sec.The output current of the PV Panel is the only parameter that taken as input to the SA MPPT Algorithm. The Output of the Proposed MPPT function is Vref which is converted into duty cycle and is given to PWM generator. It generates gate pulses which is used to control (ON&OFF) the IGBT switching device of the DC-DC Boost converter.

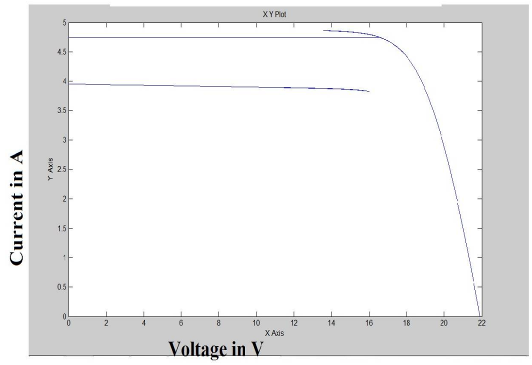

Fig.2 V-I Characteristics of 80W PV System

The Simulink model of PV system can be verified by means of its V-I characteristics and P-V characteristics curve. Fig.2shows the V-I characteristics curve of PV system at initial condition the Short circuit current is 4.7A, Voltage is zero. Its Output Power is also Zero. It is observed that voltage is gradually increasing from zero to 17.9V (max voltage) its current value is constant and remains in Isc. After this point(Vmax) ,current is suddenly decreased to zero,whatever may the value of voltage. That knee point is known as Maximum Power Point where the PV system operates at its maximum efficiency.

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Table 1.Specification of STP080S-12/Bb PV panel under STC

Parameters	Value
Maximum Output Power (Ppv)	80 W
Short circuit Current (Isc)	4.95 A
Open circuit Voltage (Voc)	21.9 V
Current at Power max (Imax)	4.58 A
Voltage at Power max (Vmax)	17.5 V
Insolation	1000W/m^2

The Fig.3 shows the P-V Characteristics of the PV system. At the initial point, the P-V curve starts from Zero point, there is no Output power. The P-V characteristics curve starts at zero and gradually increasing to meet a peak point. That point is known as maximum power point and suddenly the power decreases whatever may value of current. Finally the curve reaches at its 21.9V (Voc). By the P-V characteristics curve, we can easily find out, at which point the maximum power is generated and corresponding voltage also verified.

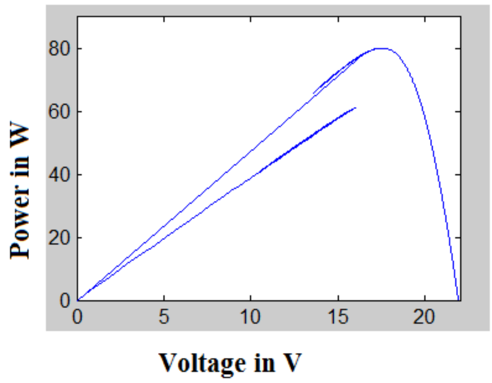

Fig.3 P-V Characteristics of 80W PV System

Modeling of PV Cell

Solar PV cells are fabricated with a single P-N junction semiconductor material. Therefore the equivalent circuit of simplified PV cell consists of a current source(Iph), a diode(D1),a shunt resistant(Rsh) and a series resistor(Rs) across the load. The equivalent circuit of Single Diode Model PV cell is shown in Fig.4.

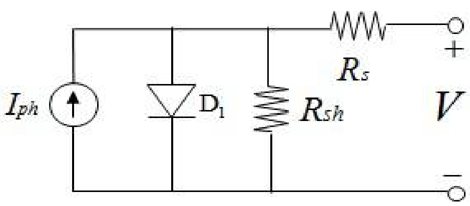

Fig.4 SDM of PV Cell

Using superposition principle in the equivalent circuit of PV cell output current is expressed as

$$I = I_{pv} - I_d \text{..........(1)}$$

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Where

$$I_{pv} = [I_{sc} + K_I (T_c - T_r)] \cdot G \text{.........(2)}$$

I_{pv} is the the light generated current of the solar cell is mainly depends on the solar irradiation level and its working temperature, which is expressed as

where, I_{sc} is the short-circuit current of cell at 25°C and 1000W/m^2, K_I is the short-circuit current temperature co-efficient of cell, T_c and T are the working temperature of cell and reference temperature respectively in °C.

I_d is the Shockley equation and it can be expressed as

$$I_d = I_s \left\{ \exp\left(\frac{q(V + IR_s)}{AkT_c} \right) - 1 \right\} \text{......(3)}$$

where, I_s is the diode saturation current, q is the electron charge, V is output voltage of PV cell, I is the output current of PV cell, A is the diode ideality constant, K is Boltzmann Constant, T_c is the cell temperature.

The output current of PV cell is expressed as

$$I = I_{pv} - I_s \left\{ \exp\left(\frac{q(V + IR_s)}{AkT_c} \right) - 1 \right\}$$

DC-DC Boost converter

The converter is to convert the low voltage to high voltage level when is connected between the PV system and the load. The generated PV system power should meet the load condition, here main work of the converter is to conditioning the PV system power.Fig.5.shows the Simulink model of DC-DC Boost converter. The boost converter operates under step up mode and uses single switch for its operation. Turn ON and OFF of the switch is controlled by the MPPT algorithm.Simulink model of DC-DC boost converter is shown in Fig.5.The output of the SA MPPT function is Vref which is given to PWM Pulse generator. It gives corresponding gate pulses to the IGBT switch in the DC-DC boost converter. The specifications of DC-DC Boost converter shown in Table 2.

Table 2 Design Parameter of Boost Converter

Parameter	**Value**
Resistance	20Ω
Inductance	500µH
Capacitance	47µF
PWM Modulation frequency	20KHz

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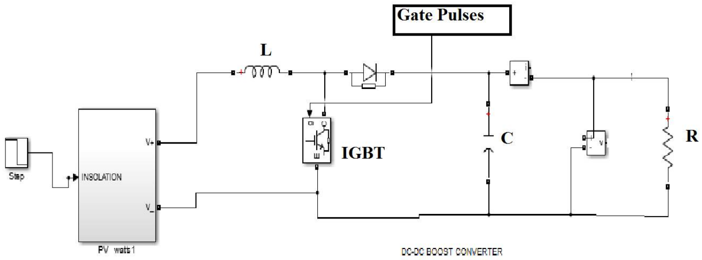

Fig.5.Simulink model of DC-DC Boost converter

III. MPPT CONTROL ALGORITHMS

SOFT COMPUTING TECHNIQUE –SA MPPT ALGORITHM

Simulated Annealing (SA) is one of the Optimization Technique. This algorithm is inspired from process of annealing in metal work for strengthening the metals. In mechanically work temperature is gradually increased until the metal melts in a heat balance. Then, it is cooled carefully until the particles are rearranged in the ground state of solid. Fig.6 shows the flow chart of SA algorithm.

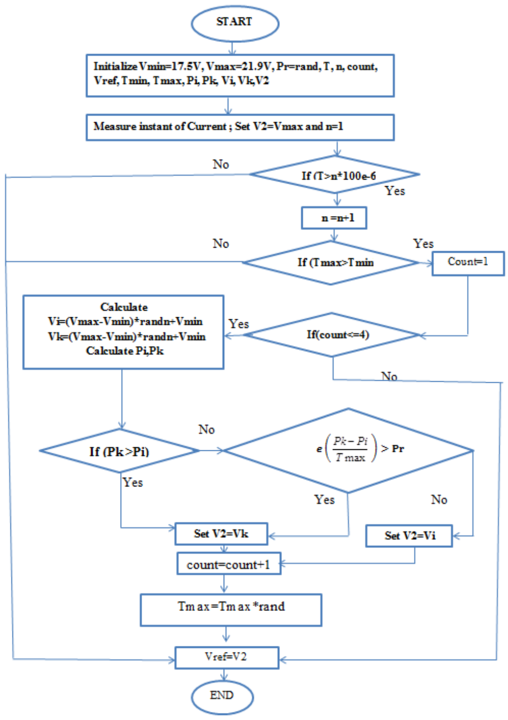

Fig.6.Flowchart of SA Algorithm

For each Step it will get Ipv reading and calculating the V(i) and P(i).Continuously searching MPP point when P(i) is greatest of all other neighboring points.

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IV. SIMULATION RESULTS ANALYSIS

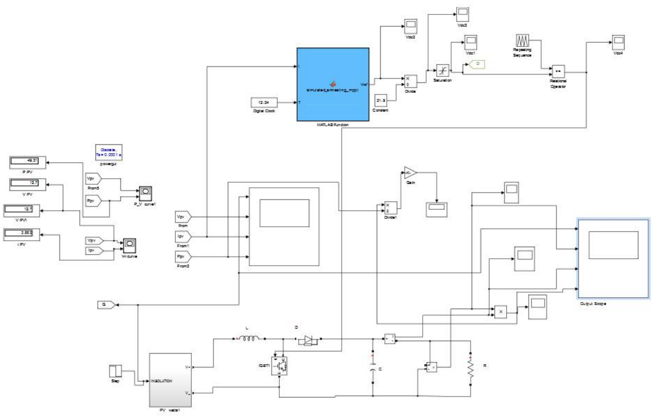

Fig.7. Simulink Model of Soft computing based MPPT Algorithm

The designed PV System in the model of 80W.By the proposed SA MPPT is mainly used to attain MPP under changing insolation conditions. Solar panel modeling can be done by Matlab Simulink Software.Fig.7. shows the Simulink design of PV system. It contains PV modules or arrays which convert solar energy in the form of solar irradiation into electrical energy. In the PV Module 36 PV cells are connected in series to generate the output voltage of 17.5V and 4.58 A at 1000 W/m^2 insolation.

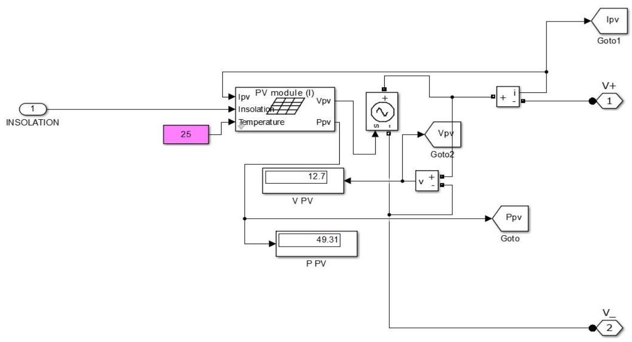

Fig.8.Simulink model PV System

The Solar PV panel output voltage, output current, output power for the given input insolation of 1000W/m2 initially then to decrease 800 W/m2 at time t=0.5 seconds are presented in Fig.9.

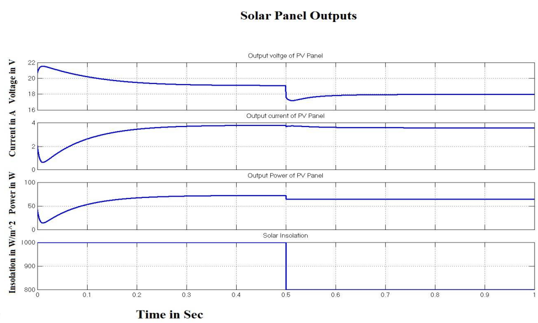

Fig.9.Solar Panel Output voltage, current, power and input insolation waveforms

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The irradiance value of 1000 W/m^2 is applied for duration of 0.5 Sec, the corresponding Output power is 80W and then irradiance is decreased to 800W/ m^2 and applied for second half cycle which produces output power 70 W.The Output voltage is 40V and current is 2A Fig.10.shows Output Voltage, Current and Power under Uniformly Varying Insolation by SA MPPT Method.

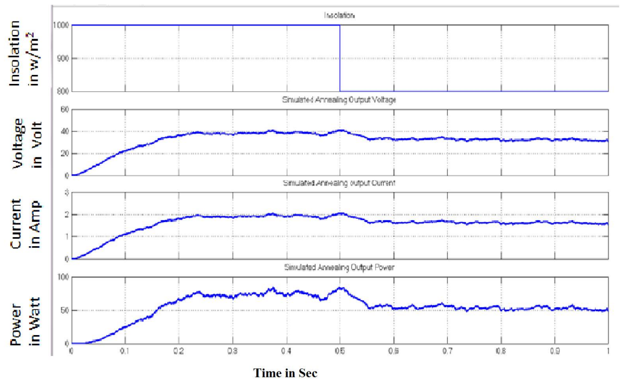

Fig.10.Output Voltage, Current and Power under Uniformly Varying Insolation by SA MPPT Method

A constant uniform irradiance is giving to the PV system for the time period of time=1Sec and corresponding Output Power is 80W,output Voltage is 40V and current is 2A. Fig.11.shows the Output Voltage, Current and Power under Constant Insolation 1000W/m^2 by SA MPPT Method.

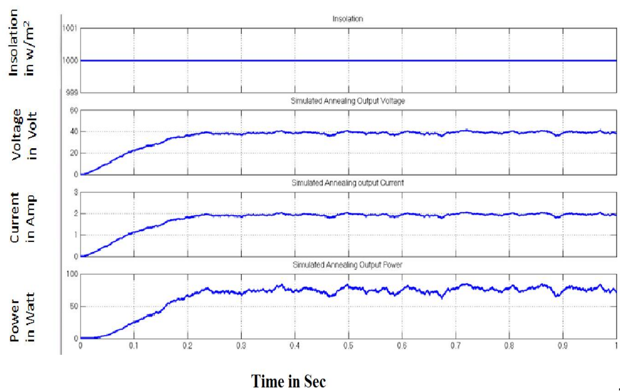

Fig.11.Output Voltage, Current and Power under Constant Insolation 1000W/m^2 by SA MPPT Method

A constant uniform irradiance is giving to the PV system for the time period of time=1Sec and corresponding Output Power is 75W,output Voltage is 40V and current is 2A. Fig.14.shows the Output Voltage, Current and Power under Constant Insolation 800W/m^2 by SA MPPT Method.Table.3 presents the comparison and analysis between the results of Modified P&O algorithm and SA MPPT algorithm.

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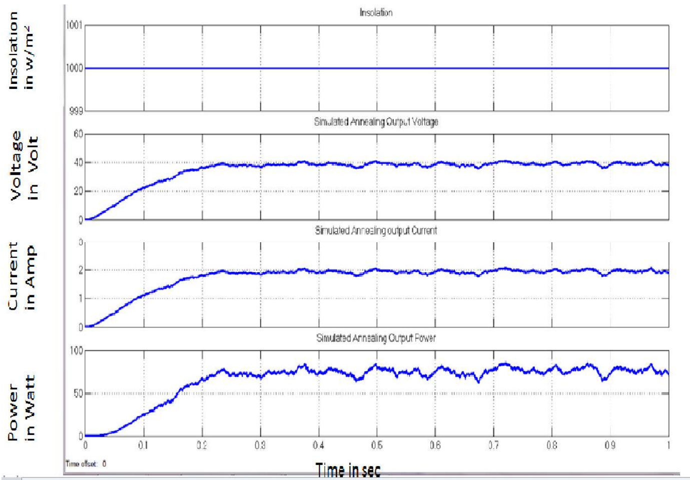

Fig.14.Output Voltage, Current and Power under Constant Insolation 800W/m^2 by SA MPPT Method

V. CONCLUSION

This paper Soft Computing Technique based MPPT Algorithm for the PV systems under varying irradiance. The Modified P&O MPPT algorithm depends upon the PV panel current, voltage as well as insolation and producing noisy responses at load. The Proposed SA based MPPT algorithm is mainly concentrated for the tracking of Global MPPT for the system and it is achieved only with the current (Ipv) sensing circuit. The simulated annealing algorithm is following best optimization strategy to find out the optimum voltage set point to track the Global operating point. So the PV panel current is only in the need here and the over cost for the implementation a well as the computational effort is less when compares to the later MPPT. The simulation is carried out for the 80W solar systems and the results are validated for the constant as well as the varying insolation levels. The simulated annealing algorithm is producing the maximum power output with reduced noise level in all waveforms. On the basis of efficiency the simulated annealing based GMMPT leading the SA MPPT algorithm by producing the maximum efficiency.

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